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MANUFACTURING PROCESS USING POLYMERIC MATERALS & AREAS OF APPLICATION OF NANO TECHNOLOGY

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ABSTRACT

In the world of manufacturing significant changes are taking place. These changes are having a profound impact on the world in a technological society. Every day we use hundreds of manufactured items, so it is very essential for mechanical engineers to be aware of the latest trends in manufacturing processes. The motive behind this work is to provide the important Nano manufacturing processes which would revolutionize the technological world. Our work provides deep knowledge of these processes and the vast area of application of Nano technology. Covering from robotic world this paper has touched the depth of application of nanotechnology in medicine area. Our research would revolutionize the nanotechnology world and will prove a great help for a young researcher and a stepping stone for the future technology based on Nanotechnology.

KEYWORDS: Nano Manufacturing, Polymers, Electro Spun Nano Catalyst

INTRODUCTION

Scientific breakthrough in Nano science has come at a surprisingly rapid rate over the past few years. The transfer of Nano science accomplishments into technology, however, is severely hindered by lack of understanding of barriers to manufacturing in the Nano scale dimensions for example, while shrinking dimensions hold the promise of exponential increases in data storage densities, realistic commercial products cannot be realized without first answering the question of how one can while millions and billions of Nano scale devices together, or how one can prevent failures and avoid defects. Most Nano technology research focuses on surface modification, manipulating several to several hundred particles on molecules to be assembled into desirable configurations. There is a need to conduct fast massive directive assemblies of Nano scale elements at high rates and overlarge areas. To move scientific discoveries from the laboratories to commercial products, a completely different set of fundamental set of research issues must be addressed- primarily these related to viable commercial scale- up of production volumes, process robustness and reliability, and integration of Nano scale structures and devices into micro-, meso-, and macro scale products. The field of Nano manufacturing is incredibly broad, cutting from all industries and scientific realms. Although much of the current nanotechnology research and literature is focused on semiconductor precision and ceramic based materials, these materials have limitations due to lack of flexibility and relatively high densities properties in which polymers excel. Polymers also lend themselves to fabrication using high rate and continuous processing. As a result it is expected that polymeric materials will play an important role in the nanotechnology revolution, especially given recent progress in conductive an optical polymers.

Some of the potential result of Nano manufacturing includes extruded multi component thin films of conformable, high-density data or energy storage; injection molded low cost calibration standards, electro spun nanowires and Nano textiles for circuits. If these examples of valuable polymer Nanomaterials are to become a commercial reality, it is necessary to understand how to create high-volume, low cost processing solutions [1].

Nano manufacturing is likely to look quite different from current macro scale processes. By making modifications to existing equipment, however we can economically and efficiently investigate fabrication of continuous fiber, continuous sheet and Nano scale features. In order to make these processes a commercial reality it is necessary to understand the fundamental science affecting the Nano scale processing of plastics. At these scales on the order of the molecular size, interfacial behavior becomes a dominant mechanism. The focus of the work is to understand the effect of polymer properties and the process conditions on “internal” interfaces between phases in polymer blends and on the external material/ tooling interface.

Internal (Plomer-Ploymer) Interfce

Interfacial effects in the blends and multilayered structures are extremely important to the bulk properties. This interface and the resulting morphology are dependent on number of factors, both thermodynamic and kinetic. While research has been conducted on macro scale systems and Nano scale interfaces, limited work has been done to control and understand the control interfaces in polymeric materials at the Nano scale under realistic processing conditions. The interfacial behavior and resulting morphology in blends and multilayer systems depend on number of factors, including the interfacial tension between the two materials. Generally the closer in solubility parameter the two materials, the better the quality of the blend, as a result of the smaller domain size of the dispersed phase. For multilayer systems, wide difference in solubility parameter can result in weak adhesion between layers. Under realistic Nano processing conditions, kinetic effects will assume more importance; thus, the role of viscosity and elasticity in interfacial control must be also understood. Molecular weight of the two polymers is another important factor, both from the aspect of thermodynamics of phase separation, and also as a result of its effect on viscosity and elasticity.

The fundamental role of polymer properties on interfacial development and control between internal polymer-polymer interfaces is focus of this section. Two approaches are discussed. First, we will look at bringing two different polymeric streams together and determining the factors that are important in maintaining interfacial control and layer uniformity when the size of layers approaches the Nano scale. This approach will rely on the extrusion methods that bring two or more layers together under controlled conditions. The second approach examines self-assembly techniques, where two polymeric materials initially blended together are designed to separate into Nano scale phases or layers during processing. This approach will use electro spinning techniques to produce Nano fibers withcontrolled morphology within the fiber itself [1].

Interfacial Instability in Nano Layer Melts-Multylayer Extrusion

When application needs cannot be met with use of a single material, multiple materials are employed to provide the necessary requirements. One advanced method to create multilayered materials employs co extrusion technologies. While typical products have two to seven layers, films with up to 2625 strata have been reported. Baer et al have created symmetric multilayer materials using a modification of a feed block technology. Schrenk et al manufactured multilayer films with up to 4097 layers, but as the number of layers increased and the thickness of each layer decreased, the individual

layers became discontinuous due to flow instabilities. This behavior is an example of the issues unique to maintaining layer identity and uniformity on the Nano scale. In this work we study the effect of polymer properties on the development on the flow instabilities in Nano layered extruded films. Flow instabilities, as shown in figure are an interfacial phenomenon and result in a reduction in properties, for example, mechanical, optical or barrier. Non uniform layers can also be found in the absence of viscosity differences as a result of the elasticity of the polymer. Shrenk et al have suggested that flow instabilities occur when the interfacial shear stress reaches a critical value. Another issue relevant to co extrusion is the phenomenon of viscous encapsulation from the system attempting to achieve minimum energy dissipation. Viscosity differences result in no uniform layers from "viscous encapsulation" of the higher encapsulated material by the lower viscosity resin as the higher viscosity material pushes into the lower viscosity material.

Many of these instabilities are studied in fully developed flow. However in a real co extrusion process one must also consider the effects of two converging melt streams. These types of studies have important implications in die design. When the two melt streams converge, material at the interface must accelerate from zero to its equilibrium velocity. The length required for the interface to reach equilibrium increases as the viscosity ratio increase and the less viscous material will have larger shear rate in systems where the two streams have equal flow rates. In these converging streams the higher-viscosity material will push into a lower viscosity material. Extensional flows are this merging is also important.

Controlled Phase Seperation in a Polymer Blend-Electr Spun Nano Fibers

Electro spinning procedures submicron sized fibers through the use of a strong electric field and a polymer solution. Typically, a polymer solution is fed through a pipette. A high voltage electrode (10 to 20 kV) placed in the solution charges the polymers. When the repulsion force exceeds the surface tension at the tip of the pipette, a jet of liquid is repelled from the pipette toward the ground plate. Electro spinning has been used in number of laboratories to produce nonwoven mats of Nano fibers for a wide range of polymers. The structure of the electro spun Nano fibers depends on a variety of factors including molecular weight, concentration, viscosity and applied field strength. Characterization of formation of electro spun Nano fibers by scanning electron microscopy (SEM) and transmission electron microscopy (TEM) showed that solution viscosity, net charge density carried by the electro spinning jet and the surface tension of the solution were the main factors.

In spite of plethora of work in electro spinning, there have been relatively little efforts toward control of the internal morphology of Nano fibers prepared from polymer blends. As depicted in figure the use of the block co polymers and blend offers the potential to develop unique fiber architectures, such as core-sheath structures or hollow fibers and continuous structures. Possible applications include development of nanowires from blends of a conducting polymer and an insulating polymer or controlled delivery systems from porous or hollow fibers. These interesting potential applications have led to research in developing techniques to prepare these types of structures. One approach is using Nano fibers as a template for depositing other polymers. Core-sheath fibers have been prepared by chemical vapor deposition of poly (p-xylylene) (PPX) [1]. One simple is to electro spin these structures directly from a solution of both polymers. Producing the types of molecular architectures depicted, using this approach requires better understanding of what material variables need to be controlled. The phase morphology of polymer blend depends on a number of factors, both thermodynamic and kinetic. Unlike solution cast films, where great care taken to obtain equilibrium morphologies, in the electro spinning process, the solvent evaporates within time scales down to the millisecond range so that the kinetics of domain formation may play a larger role in controlling the development of specific morphologies in electro spinning. Solubility parameters,

viscosity and molecular weight are expected to be the most important factors in control of the molecular architecture, while the solution viscosity is known to be an important parameter in overall electro spun fiber geometry. The bulk viscosity is expected to be important as the solvent is evaporated and the solid polymer properties assume more importance during morphology development.

External Polymer Tool Interface

Control of geometric features depends on an understanding of the interaction between the polymer material and the tool. Whether the geometries of interest are molded Nano features and controlled Nano fibers orientation the “external” interface regions plays a dominant role. The work described below includes both rigid (metallic) and non-contacting (electrified) tooling by modifying the injection molding and electro spinning processes. Tooling is typically metallic for extrusion and injection molding. Even at macro scale processing, this polymer tool interaction is critical for control of heat transfer, surface finish and defects such as jetting. With electro spinning, the tool is the electric field. This provides a useful method by which to study the effect of study the effect of surface charge and charge transport in polymer Nano fibers.

Electric Field Effects on Polymer Jets-Controlled Deposition and Orientation of Electrospun Nano Fibers

Many other applications can be envisioned for ultrafine fiber assemblies with controlled 2 or 3 dimensional textile architectures. Example of this include tissue engineering scaffold geometries that would promote oriented cell growth, fiber membrane architectures that would allow selective transport of nutrients and waste products to micro bio reactors, and 3-D fiber architectures for preferential transport. In addition to specific applications of controlled Nano fiber architectures, studies of the interaction between the external electric field and the charged polymer jet provide insight into the fundamental polymer response to non- contacting electric fields.

Despite the significant growth of research activity in electro spinning over the past decade, relatively few efforts have addressed the issue of controlling fiber orientation and distribution. The natural path of the electro spun fiber is initially straight from the pipette tip and then conical about the same axis. The conical path is a result of a bending or whipping instability and appears to be responsible for the high draw ratios with axial velocities on the order of 10 m/s. while preliminary experimental results suggest that some control of the fiber deposition is possible. Many of the current models of the electro spinning process are based on electro hydro dynamics, incorporating conservation of mass and charge and momentum balance. The understanding of the charge and material transport in the space between the onset of the instability and the collector is critical for control of the distribution and orientation of fibers. The transport should become more governed by electrodynamics than by hydrodynamics as the solvent evaporates and the charge to mass ratio increases. The objective is to design experiments that will guide the development of models and novel control methods for charged polymer jet and subsequently, for other Nano scale polymer structures [1].

Interfacial Effects in the Formation of Modeled Polymer Nano Structures

Injection molding is a versatile process used to produce large amount of plastics each year. This process permits high volume, three dimensional net shapes forming of polymeric components and is generally regarded as the most cost effective manufacturing technique available for producing large numbers of replicates. Due to inherent cost of tooling, the molding process is routinely computer simulated. Although conventional filling analyses are well established, their prediction sometime fails for thin parts, sudden change in geometry and shrinkage of some materials particularly semi crystalline polymers. The requirement for molding thin walled and very small parts(micro molding) have produced

changes in equipment, particularly injection units that permit faster injection rates with short response times and higher pressures; more robust machine frames and tooling; smaller plasticating units to deliver smaller volumes of molten polymer. Modeling of such processes is forcing the use of viscoelastic constitutive equations and incorporation of pressure sensitivity into rheological measurements and models. Increasing the importance of dynamic measurement of the pressure- temperature-volume relationship and changing the models for cooling and shrinkage. Of particular importance to the production of molded Nano structures is isothermal mold filling. When molten polymer contacts the mold walls, it solidifies to form the frozen layer and more molten polymer flows between these layers to fill the part. As parts become thinner, the frozen layer becomes a major component of the part cross section, there by requiring high fill pressures and increasing residual stresses. Although rapid heating and cooling has long been considered, recent advancements in thermoelectric devices and the application of preheated thermal coatings have made isothermal mold filling viable. Previous solutions for molding thinner-walled parts have been the use of high mold and melt temperatures, the increase of the filling pressures and speeds, and restrictions on the polymeric materials, the surface of the mold wall will probably not be the standard P20 steel [1].

Application of Nano Technology

Mechanical engineers have been instrumental in developing devices such as Nanoindentors and atomic force microscopes, which are used for mechanical testing, Nano scale imaging and metrology. Issues of feedback control of such systems are unique because of the Nano scale precession required in positioning and the ability to measure forces down to Pico newton levels. Mechanical engineers issues extend to instruments for nanoparticles for aerosol detection and characterization, as well as to various forms of Nano scale imaging. Magnetic data storage technology already has many features that fall well into the nanometer size range, and requires mechanical engineering knowledge and expertise to further its development**.**

THE NANO ENHANCEMENT OF FOSSIL FUEL

Nano Catalyst

One aspect of nanotechnology that is especially important in the context of the energy sector is catalysts. A catalyst is a material that speeds up a chemical process without being itself changed in that process and catalysts have long been a stock in trade for the chemical industry. What catalyst do, they are to reduce the amount of energy needed to carry out a given chemical process for a given amount of material. Probably, the most familiar example of a catalyst in action for many of us is the catalytic convertor in a car. Here, platinum acts as a catalyst to improve the conversion of dangerous gases such as carbon monoxide and nitric oxide to carbon dioxide and nitrogen. The physics of platinum atoms, nitrogen atoms then combine to form nitrogen gas, which floats off into air. The remaining oxygen atoms combine with carbon monoxide to form carbon dioxide. The platinum remains unchanged. The same effect could be achieved through some kind of thermal process, but then a lot more energy would have been consumed with catalysis such an important part of the energy and chemical industries. There is an inherent characteristic of nanoparticles that make them more suitable than other materials to serve as catalyst, and this their size. The smaller the particle size, the bigger the surface area of the particle relative to the size. The bigger the exposed surface area the more “catalytic power”, because this power is dependent on the available surface to which the atoms from the chemical that being changed in the process can be attracted [2].

Coal Liquification

A somewhat more revolutionary, application for nanotechnology in the energy sector is taking existing fossils fuels and processing them using nanotechnology into other fossil- based fuels that overall better overall cost-to-power performance. Given that the petroleum oil is the fuel that is unattractive for many all-too-obvious reasons. The natural fuels for Nano engineering solutions would include natural gas and coal. The biggest Nano opportunity here is liquefying coal using Nano catalysts. The end result is clean diesel like fluid for which it is not especially hard to adapt vehicles. The fuel is actually clean, only in the sense that vehicles burn it cleanly; the impurities are released during the production processes. However, centralized production of pollutants and greenhouse gases allows for more effective containment than when they are being produced by every car and motor-bike on road, which is one of the reasons why cars powered by hydrogen made from fossil fuels are not as absurd as it might appear to some.

Gas Liquification

Nano catalysts can also be used to liquefy gases and this technology is at a similar stage in development to coal liquefaction. However the first commercial impact of Nano- enabled gas liquefaction will be not on hydrogen but on natural gas. If you consider natural gas purely from the perspective as a fuel, it appears to have an advantage over oil in terms of availability. At the current level of technology development, there appears to be decades more gas reserve than there are oil reserves. If deep ocean reserves of gas prove accessible, we are possibly talking centuries more of gas reserves than those of oil. Liquefying natural gas does not necessarily require nanotechnology and liquid natural gas plants are now appearing overall the world as the costs of liquefaction have been falling. Where nanotechnology seems most likely to make a contribution however is once again through Nano catalysts that make it easier to convert gas to an easily transported liquid [2].

NANO SOLAR POWER

Passive Solar Power

It is in which building materials, architectures and geographical architectures are designed in such a way that energy from sun is utilized to keep the house warm. Passive solar heating involve two main elements: south facing glass and a thermal mass to absorb, store, and distribute heat. It seems possible that nanotechnology could make a contribution here with better materials to improve both aspects of a passive solar power heating system. Passive solar has proved quite effective, although it is not a system that can be easily retrofitted, because much of its effectiveness lies in the basic design of the home or other building.

Solar Power Station

These are like all other power stations that create electricity through an electromagnetic effect. In most power stations the turbines are driven by fossil fuels and some power stations are driven by heat from nuclear power. In solar power stations, the turbines are driven by heat from concentrated solar power. This is a fairly unusual way to generate electricity and perhaps Nano technology contribution to making solar power stations more widespread with some kind of Nano structured solar collectors, but it doesn’t seem to be much of priority for Nano technologists at the present time.

Photovaltaic (PV) Systems

These are systems but come in various shapes and sizes that create electricity through the photovoltaic effect,

which is a physical phenomenon in which electrons are freed from materials by bombarding them with photons. In this case the photons are coming from the sun. Photovoltaic system is having been around for quite some time and have found number of niche applications, although they never seem to have lived up to the lofty expectations of some of their backers. Civil companies are researching how Nano engineered materials can reduce the cost of photovoltaic systems.

This important because even though the input to photovoltaic systems is free energy from the sun, the system are typically expensive, so that the cost of electricity generated in this way is significantly more costly than electricity generated by other means. In addition, the conversion of solar energy to electricity in photovoltaic is highly inefficient. It seems that PV is likely to be used initially in the form of auxiliary power sources than as a primary power sources in various circumstances. There has also been talk of inexpensive roll-to-roll printing of solar panels, using low cost PV to keep the batteries of notebook computers and cell phone charged and even painting PV cells on the walls of office blocks. Efficiencies of this type of product will certainly increase and they appear to have the potential to take PV in directions that it has never before been emboldened to go. Also, the efficiency of Nano engineered PV may lower than slandered PV, but in some formulations, energy is retained longer so that "Nano-PV" actually has better performance indoors and in other low light conditions. [2].

Nano Enhanced Distributed Electricity Grid of Future

Nanotechnology could push the electricity industry in both directions over a period of time. Firstly it may lead to improve economics for smaller generators, leading to a more distributed grid. Then at a latter grid, it may lead to reduced transmission costs, which work in favor of large turbines. One immediate opportunity seems to be to use nanotechnology to lower the cost of smaller nodes, making for a more distributed network. A lot of development has been seen in "mini turbines" using the same principles as large power stations but on a smaller scale. These machines compete directly with larger fuel cells for small scale industrial use and Nano enabled fuel cells should also be seen as a way that Nano technology encourages the distribution of energy generation from where we are now. For mini turbines, the impact of nanotechnology is not likely to be revolutionary but there are certainly applications for Nano crystalline metallic, ceramics and composites that can improve performance parameter especially lifetime.

Working in the other direction, toward a more centralized power system, is the possibility that highly conductive nanowire, nanotube composites and Nano-enabled superconductors would vastly improve the efficiency of the electricity grid. You could then have a relatively few power stations generating power and then disturbing them cheaply across the country or the world. Large Nano enabled batteries which would likely again use Nano catalyst, would vie with "super capacitors" built from Nanomaterials to provide electricity storage at centralized power stations, which would become efficient, because they could make electricity at times when the demand. However, it is fair to say that Nano enabled storage solutions would also play an important role in the more distributed scenario for electricity distribution.

Nano Power for Pervasive Network

Referring the energy crisis that faces the mobile communications and computing sector. Basically, the cause is that Moore's law is letting the suppliers of the cell phones, notebook computers, PDAs, and such add more and more features, but the energy density of the lithium ions battered used to power these mobile devices have been increasing at a much slower rate. The end result is the time between charges of the batteries is actually beginning to decline. The average time between charges for notebook computers has declined to about 2.5 hours. Nokia supposedly the abandoned the launch

of a new many- functioned cell phone, because its functionality put so much demand on the battery that it needed constant recharging, all of which means that we stuck with using batteries in mobile devices for the next few years. There are, however, some ways in which nanotechnology can help to improve the performance of lithium ion batteries. Most notable of these is to replace the conventional carbon anode that is used in lithium ion batteries with Nanomaterials that provide a bigger surface area for electrons to collect on, which translates into more power from same sized battery, faster charge times, and a longer-lived battery [2].

Nano Robotics

Nano robotics is the technology of creating machines or robots or close to the scale of nanometers. More specifically, Nano robotics refers to the still largely hypothetical nanotechnology engineering discipline of the designing and building Nano robots. Nano robots would be typically devices ranging in size from 0.1-10 micrometers and constructed of Nano scale or molecular components. As no artificially non- biological Nano robots have so far been created, they remain hypothetical concept at this time. In other words we can say that, robot which alloys precision interactions with Nano scale objects, or can manipulate with Nano scale resolution. Following this definition even a large apparatus such as an atomic force microscope can be considered a Nano robotics instrument when configured to perform Nano manipulation. Also, macro scale robots or micro bots which can move with Nano scale precision can also be considered Nano robots. Just as solar cells utilize energy from their surroundings, other sources of power may be beams of the light or radio frequency energy that track [3].

Nano Filtration

Nano filtration is a relatively recent membrane process used most often with low TDS waters such as surface water and fresh groundwater, with the purpose of softening and removal of disinfection by-product precursors such as natural organic matter and synthetic organic matter [4]. Nano filtration is also becoming more widely used in food processing applications such as diary for simultaneous concentration and partial demineralization. In much of the developing world, clean drinking water is hard to come by and nanotechnology can be solution. While Nano filtration is used for the removal of the other substances from a water source, it is also commonly used for the destination of water. As seen in recent study in South Africa, tests were run using polymeric Nano filtration in conjunction with reverse osmosis to treat brackish ground water.

These test reduced potable water, but as the researchers expected, the reverse osmosis removed a large majority of solutes. This left the water void of any essential nutrients placing the nutrient levels below that of the required world health organization standards. This process was probably a little too much for the production of potable water as researchers had to go back and add nutrients to bring solute levels for the drinking water [5].

Nanotechnology in Regenerative Medicines

Nanomaterials may actually be better, in that they are stronger and more durable than the real thing. A burn victim may have his or her burned skin replaced with a nanomaterial that looks and feels like a real skin, but is much more durable than real skin. However, this durability may translate into people who have undergone the procedure looking much younger than their actual chronological age and it is not unlikely that in such a case new cosmetic surgeries will emerge that use the same technology to make 60- years-olds look 40 years old. It is possible that the technology could be used as a step to making lifelike robots for the work and pleasure applications. The “unique selling proposition” of nanotechnology

in the context of regenerative medicine is that it can be used to build “spare parts” for the body that are finely enough sculptured and textured to make them excellent substitutes for the real things.

Nano Gels

One of the nearest to commercialization applications in regenerative medicine for Nanomaterials are gels that provide structures much like trellises used to “train” plants over which damaged nerve cells can grow as they regenerate. Similar gels have been on the market for a while, which should help the Nano gels find acceptability quickly. The advantage that Nano engineering brings to the table here is that a Nano scale trellis fine- tunes the regenerative process, so that much of the original functionality is regained [2].

Organ Replacement

Completely artificial organs have been around for several decades, but have never really become as popular as once thought. It is possible that new Nanomaterials, coupled with Nano electronic devices could make very significant contributions to constructing artificial organs. A more interesting, and perhaps, even a more likely direction, is to use “nanotrellises” of the kind described above to grow complete organs. NASA has used this approach to grow heart cells and connect them up in a way that actually allows them to “beat” when put in correct artificial environment. Growing a complete heart is a very long way off and may seem more difficult to achieve than constructing a completely artificial heart.

Better Blood

A number of other less dramatic Nano enabled procedures should also help improve the cardiovascular system. There has been talk of creating artificial blood cells, which would consist of Nano spheres filled with high pressure oxygen that could be injected into body. This would be as much as a drug delivery system and could be used to treat heart attack or stroke victims. A somewhat less futuristic approach to deal with cardiovascular problems is what we shall dub a “Nano stent”. A stent is a device intended to keep clogged vessels open and they have been around for a while. Nano engineering however, is being applied by at least one firm, Advanced Bio Prosthetic surfaces (ABPS), to make stents better. In this case, a nonporous coating is being used to ensure that the stents has no rough edges that could hurt the blood vessels or cause inflammation and it also ensure that the stent is stronger and more flexible [2].

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